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DEFICITS AND INTEREST RATES: THEORETICAL ISSUES AND SIMULATION RESULTS

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PREFACE

This paper was written by John Sturrock, of the Fiscal Analysis Division. It was undertaken as technical background work in connection with ongoing studies of the effects of federal budget deficits on the economy. The views expressed in this paper are the author's and do not necessarily reflect those of the Congressional Budget Office or other members of the staff.

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INTRODUCTION AND SUMMARY

During the 1980s real (inflation-adjusted) interest rates have been unusually high--the ex-post real 91-day Treasury bill rate, for example, has averaged 4.2 percent compared to its average over the entire post-Korean war period of 0.9 percent. At the same time, the federal deficit has averaged 3.9 percent of GNP, well above its post-Korean war average of 1.6 percent. This would seem to confirm traditional theory that large deficits lead to high interest rates. But other factors influence interest rates as well. In addition, traditional theory has come under attack by a school that argues that deficits, in themselves, should have no effect on interest rates.

Resolution of the deficit-interest rate question is important not only because it would shed light on the workings of the economy, but for immediate practical reasons as well. The interest rate plays a central role in influencing economic activity, and understanding its determinants would aid in predicting its future course. This matters from the standpoint of budget deliberations, not only because it would improve our understanding of how budget policy may affect interest rates and the economy as a whole, but also because interest costs themselves are a significant part of the deficit.

This paper uses simulation analysis as an approach to the deficit-interest rate question. This involves comparing the results of alternative tax and spending policies on statistical models of the economy. Because construction of such models typically appeals to theory, the paper first offers a brief description of the theoretical issues. It then examines the results of simulation experiments. A companion paper, Iden and Sturrock (1989), surveys an alternative approach that attempts to test directly for a relationship between deficits and interest rates.

THEORETICAL ISSUES

Most economists adhere to the traditional view that lowering deficits acts to lower interest rates because it eases competition with private demands for credit. In the long run, the size of the interest rate response to a sustained deficit reduction will depend on how the demand for and supply of capital themselves respond to the interest rate. In the short run, the interest rate response will depend particularly on the extent to which output and income are affected and on the response of money demand to the interest rate, income, and wealth. It will also depend on the way that the deficit is reduced and the response of the monetary authority. Some economists also stress that the results will depend on whether the deficit reduction was anticipated by the public. Others argue that the interest rate response will be significantly reduced by international financial transactions--essentially because the change in credit demand implied by the deficit reduction is smaller in relation to the world economy than it is relative to the domestic economy.

Some economists argue that these effects may be substantially, or even entirely, offset by individual saving behavior. They argue that a deficit must necessarily be backed by higher taxes in the future, and that people adjust their

saving to be able to pay any taxes that they expect to be increased during their lifetimes. Reducing the deficit, according to this argument, correspondingly reduces the need to save and lessens the easing of interest rates. A group known as neo-Ricardians represent a polar example of this view by arguing that a deficit reduction will be exactly matched by decreased private saving. This follows, according to their argument, because individuals provide not only for any increased future tax liabilities that might occur in their lifetimes, but in the lifetimes of their descendants as well. If lower private saving exactly offsets reduced deficits, the balance of supply and demand in the credit markets, and therefore the interest rate, remains unaffected.

SIMULATION RESULTS

To assess the estimated size of the interest rate response to deficit reduction, the Congressional Budget Office (CBO) surveyed six studies that simulated econometric models. But the simulations did not all involve the same policy experiment for each model, so the results across models are not strictly comparable. For reference, therefore, CBO simulated four econometric models for this study under a variety of policy assumptions. Each policy experiment was conducted on all of the four models. The results of controlled simulation experiments obtained from an extensive international study sponsored by the Brookings Institution are also reported.

Because model simulations account, in principle, for all interactions among variables, the simulated deficit reduction is likely to differ from the static reduction--the reduction that would obtain if only tax or expenditure policies changed and all other variables remained the same. Most models suggest that output and income will initially fall as a result of deficit reduction, and this will lead to lower revenues than would obtain in the absence of the decline in income. Hence the simulated deficit reduction would initially be less than the static reduction. On the other hand, a fall in interest rates will, in itself, lead to a lower deficit because interest costs on the debt are an important part of the deficit. Eventually, output will largely recover, and, with lower interest rates, the simulated deficit reduction will be greater than the static reduction.

The model simulations suggest a wide range of results. Those surveyed by CBO indicate that by the third year a permanent static deficit reduction of $50 billion would cut short-term interest rates by between 1.4 and 2.6 percentage points. Results from the models CBO simulated depend critically on the experiment conducted. If the monetary authority makes no effort to counter the contractionary effects of the deficit cut, the simulations suggest that by the third year a once-for-all static deficit reduction of $50 billion would lead to changes in all interest rates--long-term (nominal) and short-term (both nominal and real)--ranging from virtually no change to a fall of about one percentage point. If the monetary authority is assumed to return GNP to the level that would have obtained if there had been no deficit reduction, the effects on all interest rates by the third year range from virtually no change to a fall of about three percentage points. These two monetary policy assumptions almost certainly bracket the actual monetary response to such a deficit reduction.

The Brookings study suggests that a once-for-all static cut in purchases of $50 billion would, on average, reduce all rates by about one percentage point by the third year if the monetary authority maintained the same money growth that it would have in the absence of the cut. The results ranged, however, from nearly no change to a fall of about three percentage points in the nominal short-term rate, and from nearly no change to a fall of about two percentage points in the real short-term rate and in the nominal long-term rate. Again, interest rates would typically fall even more if the monetary authority followed a more expansive policy.

Because interest costs contribute to the deficit, lower interest rates lead directly to lower deficits, other things equal. CBO made rough calculations of the extent to which lower interest rates would reduce the deficit for each of the simulations conducted by CBO or reported by the Brookings project. The calculated responses reflect the current estimate that a permanent reduction of one percentage point in both long-term and short-term interest rates in itself would reduce the deficit by $16 billion by the third year and by $30 billion by the sixth year.

The results of the calculations are scattered, following from the dispersion of interest rate responses. The simulations conducted by CBO indicate that, by the third year, lower interest rates would have contributed between $1 billion and $13 billion to deficit reduction when nonborrowed reserves were held to baseline values, and between 0 and 41 billions of dollars when GNP was returned to baseline values. The average calculated contribution by the third year indicated by the Brookings project results was $15 billion, but the calculations ranged from $2 billion to $36 billion.

CAVEATS

The responses cited should be taken advisedly, because results from any model can depend, sometimes dramatically, on the design of the policy experiment and on economic conditions at the start of the simulation. In addition, estimated responses can change, again sometimes dramatically, when models are updated.

The simulations suggest possibly large interest rate effects, but they do not resolve the issue. The simulation results are not persuasive to those unwilling to adopt the same assumptions that the model builders use, and the issue awaits further evidence. The models are constructed by statistically estimating relationships among data, but such estimates necessarily require assumptions about the structure of the economy. Typically, the assumptions are such as to guarantee that deficit reductions will cause interest rates to fall, although the extent of the fall can differ widely depending on apparently equally plausible assumptions about and estimates of the channels of influence. Most economists accept the restrictions that lead to a deficit-interest rate link. But studies surveyed by Iden and Sturrock (1989) that conduct direct statistical tests of a deficit-interest rate relationship fail, as a whole, to establish unambiguously its significance.

Finally, it should be noted that the level of the interest rate, in itself, is not necessarily the most important implication of deficit policy. This stems from the fact that high interest rates are not in themselves considered to be the real burden of the

deficit. Most, though not all, economists believe that, in the long run, the real burden of high deficits is the reduction of future income that they imply because they absorb funds that would otherwise be used to finance productive capital. In this view, financing public consumption with deficits makes the current generation better off at the expense of succeeding generations. The interest rate is a poor guide to the extent of this transfer between generations--in an extreme open-economy case it could occur even with no change in the interest rate. Transfers between generations--as well as other issues that arise in connection with federal debt policy--are of substantial importance, but are beyond the scope of this paper. Resolution of the deficit-interest rate connection will illuminate such issues, but they must be decided on their own grounds.

THEORETICAL ISSUES

Recently substantial theoretical controversy has arisen over the economic consequences of deficit reduction, including the effects on interest rates. This section provides a brief, stylized description of the disputed issues. It is intended as a cursory introduction, not as a complete review. For clarity, arguments are often stated in their most naive forms in order to emphasize their essence, if not preserve their subtleties.

Some terminological conventions have been adopted throughout to facilitate the discussion. In principle, the deficit is defined as the change in the net assets of the government. For a number of reasons this may differ from the National Income and Products Account (NIPA) deficit used later in the simulation studies. Iden and Sturrock (1989) discuss the implications of such differences.[1] Discussion of changing the deficit refers to changing the level of the deficit when other things remain equal--the "static" or "structural" change in the deficit that can be directly determined by policy. The observed deficit that is determined by both policy and cyclical events will usually be referred to as the "actual" or "realized" deficit, unless the distinction is clear from the context. In addition, unless otherwise specified, it is assumed that changes in the deficit are not monetized--that is, the monetary authority is assumed not to change its holding of government debt, so the change in the deficit is fully reflected in privately held bonded debt of the government. The term "interest rate" by itself refers to the market, or nominal, interest rate, whereas the terms "output" and "capital" refer to the respective real (constant price) values. Finally, the terms "interest rates" and "the interest rate" are used interchangeably unless a specific case is being discussed in which interest returns to various assets would not all rise or fall together.

The discussion focuses on pure deficit effects, abstracting from the price incentives that tax and expenditure policies may imply in themselves. For example, the Council of Economic Advisers argued in the *Economic Report of the President* (1985), p. 35, that interest rates were then high, in part, because the net effect of business tax legislation of 1981 and 1982 increased business demand for capital, putting upward pressure on the real interest rate. Similarly, if private saving responds positively to the real after-tax interest rate, lowering personal tax rates should, other things equal, act to lower the interest rate. This section does not usually consider such incentive effects of fiscal policies, only the direct effects of deficits in themselves.

THE LONG-RUN EFFECT OF DEFICIT REDUCTION

Long-run analysis considers abstract economies in which all adjustment processes have been completed and all markets are in equilibrium. Because long-run analysis abstracts from many complicating factors, studying the effects of deficit reduction

1. Some economists strongly argue that deficit policy should be defined in terms of the present values of net payments to government by current and future generations. See Auerbach and Kotlikoff (1987), pp. 103-110.

in the long run is relatively straightforward. The long run will therefore be considered before turning to the short run. Three principal views are considered: the traditional view in a closed economy, which holds that reducing the deficit would reduce interest rates; the open-economy variant, which holds that international financial flows would reduce--or in the extreme case eliminate--the effect of any single country's deficit on the interest rate; and a neoclassical approach whose extreme is represented by the neo-Ricardian view, which holds that interest rates are entirely unaffected by deficits in either a closed or an open economy.

The Traditional View in a Closed Economy

The traditional view holds that, in a closed economy (one with no international sector), permanently lower deficits would reduce total credit demand. This would lead to a lower real interest rate and a correspondingly higher capital stock and output in the long run.[2] Given the same long-run money growth, and therefore the same long-run inflation rate, the nominal interest rate will fall as well. The changes in private capital and output and in the real interest rate will all be smaller the more interest-sensitive is the supply of capital. On the other hand, the increase in private capital and output will be larger, and the fall in the real interest rate smaller, the more interest-sensitive is the private demand for capital. Therefore the amount by which the real interest rate falls is not itself an indication of the extent of resource reallocation or redistribution between generations that the deficit implies.

The Effects of an Open Economy

The traditional view is modified by assuming an open economy in which goods and capital (or asset claims on capital earnings) can flow across national boundaries. If asset claims are perfectly substitutable internationally, real interest rates on comparable securities will be equalized throughout the world.[3] Although lowering the deficit will reduce total domestic credit demand, any tendency for the domestic real interest rate to fall will be reduced as investors seek higher returns from foreign securities. The increased demand for foreign currency with which to buy such securities will cause the exchange value of the domestic currency to fall instead. In the extreme case of a country so small relative to the world economy that its actions have no appreciable effect on international capital markets, reducing the deficit will leave the real interest rate and domestic capital stock unaffected in the long run. Even in a country like the United States large enough to affect international capital

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2. The discussion assumes that the deficit is not being used to finance government capital projects. There is general agreement that it can be appropriate to finance government capital projects by issuing debt because the asset acquired matches the increase in bond liability. It is also assumed that the deficit is not being used to finance projects that directly substitute for private activities.

3. This assumes an equilibrium in which exchange rates are not expected to change. Otherwise, the interest rate prevailing in a country would rise above (fall below) the world interest rate to reflect the expected rate of depreciation (appreciation) of its currency.

markets, the real interest rate response in an open economy will still be smaller than that predicted by the traditional view in a closed economy.[4]

Deficits matter, however, even in the extreme open economy case when the real interest rate and domestic capital and output are unaffected by deficit policy. The deficit reduction effectively causes a net flow of domestic funds, which would otherwise finance the deficit, to be invested abroad, thereby increasing the domestic net asset position against the rest of the world. Profit and interest earnings of these assets will be returned as income to citizens in the home country. Therefore the deficit reduction leads to an increase in the wealth, though not the capital stock, of the nation as a whole.[5] Again, the behavior of the real interest rate is, in itself, an unreliable guide to the allocative and distributional effects of the deficit.

Offsetting Changes in Private Saving

Finally, the effect of deficits on interest rates can be substantially reduced if individuals expect deficits to lead to higher taxes in the future. An extreme view in this context is held by the neo-Ricardian school led by Barro (1974, 1976) which maintains that deficits will have no effect on either real or nominal interest rates even in a closed economy. This conclusion stems from the contention that government bonds are not part of aggregate private net worth. While government bonds are assets to the individuals who hold them, they represent an equal amount of liabilities to citizen-taxpayers as a whole.

According to the argument, individuals see that taxes must be raised in the future to pay part of the interest on the bonds issued to finance the deficit, and they save to provide for this future tax liability.[6] Even if they do not expect to be alive when taxes are raised, they do not want to reduce the consumption possibilities of their descendants by passing on this liability. (This behavior is known as intergenerational altruism.) The present value of the future tax liability is equal to the current value of the bonds, so if the deficit is reduced now, the need to save is

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4. This assumes technical conditions in international and domestic financial markets that would lead a deficit reduction to induce currency depreciation (the most likely case). If financial conditions led to currency appreciation when the deficit was reduced, the change in interest rates would be greater in an open, rather than closed, economy. This is more likely to happen when market participants strongly prefer assets denominated in their home currencies to otherwise comparable assets denominated in foreign currencies.

5. There will be an offsetting influence, however, if the capital outflow is associated with a depreciation of the home currency. This will act to reduce real domestic incomes by increasing the cost of imported goods. In addition, some of the income earned abroad is paid as taxes to foreign governments, rather than accruing to residents of the home country.

6. Monetary debt bears no interest burden, however, so it does not imply a future tax liability and does constitute part of aggregate private net worth.

reduced by the same amount. This leaves total saving, and both real and nominal interest rates, unaffected.[7,8]

The notion that the current deficit must be backed by future taxes (or by future money creation) is not unique to neo-Ricardians. It relies on the argument that the principal and interest due on current bond issues cannot indefinitely be repaid simply by issuing more bonds in the future. Trying to do so would be destabilizing because the debt relative to GNP would grow without bound.[9]

Most economists who believe that current deficits must necessarily be backed by future taxes, however, argue that a current deficit will lead individuals to save only against a rise in taxes that they expect to take effect during their lifetimes.[10] In this view, a deficit reduction would be only partially matched by a reduction in private saving if some taxpayers did not expect to be alive when taxes were lowered. Only neo-Ricardians make the additional assumption of intergenerational altruism to conclude that future taxes implied by deficits are entirely discounted by the public.

THE SHORT-RUN EFFECT OF DEFICIT REDUCTION

Among those who, unlike neo-Ricardians, consider government debt to be part of aggregate private net worth, there tends to be more controversy over the relationship between deficits and interest rates in the short run than in the long run. The issue is complicated by the fact that movements in many variables--deficits, output, and interest rates in particular--tend to be associated over the business cycle. Identifying the separate effects of a given variable requires disentangling short-term co-movements among variables. So, even if economists agreed on the long-run effect of deficit reduction, they might disagree on the transitional effects. In fact it is possible for some effects to be perverse in the short run--moving opposite to their eventual direction.

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7. Neo-Ricardians believe that government expenditure, especially when temporary as during wartime, can raise both real output and interest rates. This would occur, however, whether the expenditures were financed by bonds or taxes. See Barro (1981).

8. While neo-Ricardians do not believe deficits affect interest rates or capital formation, debt policy is not irrelevant to their world view. They stress that it is inefficient to vary tax rates continually to maintain budget balance, and that this inefficiency leads to a welfare loss. For example if tax rates went up with temporary expenditures, as in wartime, this would provide incentives to postpone earning income until tax rates were lower again. Instead, neo-Ricardians believe that relatively stable tax rates should be set that over time would take account of the projected rate of expenditure. Thus transitory fluctuations in expenditure should be financed with debt.

9. In an economy with no uncertainty, this result depends on the effective interest rate on government debt being greater than the rate of growth of the economy. (Darby (1984) argues that the after-tax interest rate on government debt is the relevant rate.) This condition has not generally been satisfied in the United States during the postwar period, but whether the instability result follows anyway in an uncertain world is an unresolved issue. See Abel and others (1986).

10. See, for example, Auerbach and Kotlikoff (1987) or Frenkel and Razin (1986).

The Keynesian View

Keynesians believe that a deficit reduction will initially reduce aggregate demand and induce a fall in output (or its growth).[11,12]. The ratio of the change in output to the change in the given expenditure (tax) is known as the expenditure (tax) multiplier. According to the Keynesian system, allowing realized deficits to rise and fall over the cycle acts automatically to help stabilize output.

As deficit movements affect short-term movements in output, these movements in output and in associated variables help to influence movements in the interest rate. The interest rate will fall both as the government reduces its credit demands and as private credit demands fall with activity. The fall in interest rates will act to stimulate aggregate demand and help eventually to reverse the initial fall in output. Because purchases affect output directly, the fall in output (and, hence, usually the interest rate) can be expected to be greater for a reduction in purchases than for a tax increase. Other things equal, output and interest rates will fall by a greater amount the more sensitive aggregate demand is to income and the less sensitive it is to interest rates. The inflation rate will also tend to fall as activity is dampened, so the course of the realized real interest rate is ambiguous.[13] It could initially rise, even though it must fall in the long run.

The extent to which interest rates fall will also depend on the initial state of the economy at the time the deficit is reduced, as well as on the response of the Federal Reserve. If the interest rate is already high, a given deficit reduction may induce a larger decline in the interest rate (and a smaller decline in output) than it would if the initial interest rate were lower.[14] Because long-term interest rates incorporate expectations of future short-term interest rates, the behavior of the long-term rate will depend on market anticipations at the time of the deficit reduction. If the market had already anticipated the deficit reduction, this would have been incorporated in the long-term rate, so it would not need to respond further when the deficit reduction actually occurred.[15] Finally, in the Keynesian scheme, if the Federal Reserve acts to counter the contractionary effects of deficit reduction, output will fall less and the interest rate will fall more than they would otherwise.

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11. The short-run response to a deficit cut will be smaller, however, if it is expected to be temporary, rather than permanent. Individuals will see that their future incomes are less affected in the temporary case and will borrow if necessary to try to maintain their current level of expenditure.

12. Blinder and Solow (1973) and Phelps (1982) discuss circumstances under which a deficit reduction would raise output in a Keynesian system (although in the case considered by Blinder and Solow, such circumstances would imply that the model was unstable). Both agree that the interest rate would fall even in these cases.

13. Raising excise or payroll taxes, however, could cause inflation to rise initially as attempts to pass the tax forward act to increase the price level.

14. This point is explained in the section discussing simulation results.

15. In fact, if market participants had expected a larger deficit reduction than was actually enacted, the long-term interest rate could rise.

The Monetarist View

Unlike the Keynesian case, deficit reduction will not lead to any co-movement between output and interest rates in a monetarist world. Monetarists believe that policy-induced deficit reduction will have no effect on total output. Instead, they think that interest rates will fall enough that interest-sensitive spending will compensate for the effect that cutting the deficit would otherwise have on output. This may occur for a number of reasons. Either of two polar conditions would necessarily imply such a result:

- Perfectly flexible wages would allow labor markets to clear continuously at full employment; with employment, and hence output, fixed, the lower deficit will imply that the interest rate will fall enough to clear financial markets and ensure that private consumption and investment are consistent with the given level of output;

- Perfectly interest-inelastic money demand (and supply) would mean that the public would be willing to hold the available stock of money only if interest rates fell enough for an increase in interest-sensitive spending to match the reduction in aggregate demand implied by the deficit cut.

Either of two other conditions might lead to no short-term change in output when the deficit is reduced:

- Highly wealth-elastic money demand would imply that as holdings of government bonds were decreased, demand for money would also decrease, putting further downward pressure on interest rates;

- Much greater portfolio substitution between bonds and equity than between bonds and money would lead to an increased demand for equity as the supply of bonds is reduced, thus intensifying the downward pressure on equity rates on which investment depends.

With no change in output or the money stock, prices will be unaffected by the deficit reduction, so the stylized monetarist model predicts unambiguously that the realized real interest rate will fall in the short run.

The New Classical View

Another group of economists, the new classical school, believes that policy-induced movements in the deficit have short-run effects on output only if they are unanticipated.[16] In this view the co-movement between output and interest rates arises from unanticipated events. Two assumptions principally account for this result: that agents collectively use all available information to form "rational" expectations of the future course of economic variables; and (the classical assumption) that prices are always flexible enough to clear all markets.

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16. Formally, given that policymakers and the public have the same information, policy feedback rules will leave the stochastic process governing output unaffected.

The assumption of rational expectations implies that, while expectations of the future are never exactly correct, over time they are correct on average and are never predictably wrong. In particular, according to this hypothesis, expectations reflect all information available in the system. This, in turn, implies that prices will reflect all available information.[17]

New classicals argue that, in a stable policy regime, the fiscal authority makes tax and expenditure decisions based on events that have occurred in the economy. The public understands the rules--formal or informal--that determine these decisions, and conditions its behavior on anticipations of fiscal actions.[18] Thus when movements in policy variables occur according to these policy rules, such movements are already reflected in the prices that will establish an equilibrium output. Therefore, fiscal actions can affect output in the short run only if they are unexpected.[19,20]

In most instances new classical theory indicates that deficit reductions, whether anticipated or unanticipated, will lower both nominal and real interest rates in the short run. But historical responses to deficit changes have depended on the public's perception of policy rules, as well as on its responses to underlying economic variables. Therefore, establishing the precise nature of the relationship will depend on identifying truly autonomous policy changes and on separating anticipated from unanticipated fiscal changes.

The Effects of an Open Economy

As in the long run, the effects of deficit reduction are likely to be reduced by international financial transactions, but some complicating factors arise. Consider the most likely case in which deficit reduction leads to depreciation of the home currency, which should lead to a rise in net exports. Without instantaneous adjustments, the fall in the domestic exchange rate may initially cause nominal net exports in terms of the domestic currency to fall until real net exports rise enough

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17. While expectations are also important in Keynesian and monetarist models, rational expectations imply theoretical restrictions traditionally unaccounted for.

18. The theory does not require that everyone has such information, but implies that arbitrage by knowledgeable market participants will lead all relevant information to be reflected in prices. Thus most market participants can rely on readily available information.

19. This does not necessarily rule out the efficacy of automatic stabilizers, because they take effect at the same time as any unanticipated events that trigger them. Their effects are thus unanticipated themselves.

20. Even with rational expectations, policy changes can affect output if frictions keep prices from instantaneously clearing markets. See Fisher (1977) and Phelps and Taylor (1977).

to offset this effect.[21] Likewise, if the exchange rate adjusts rapidly to its appropriate new level while product prices respond sluggishly (as in the Keynesian system) a temporary rise in inflation will result. If this higher inflation is anticipated, and with an unchanged real interest rate, the nominal interest rate will temporarily rise.

In addition, the nature of new classical models can lead to an ambiguous response of interest rates to an anticipated deficit reduction when the home country is large enough to affect world interest rates. Frenkel and Razin (1986) consider a model in which an anticipated future deficit reduction will lead to a decrease in the current real short-term interest rate only if the home country's marginal propensity to save is greater than the foreign marginal propensity to save. Otherwise the current real short-term rate will rise. The conclusion depends on the assumption that a current deficit must necessarily be backed by higher future taxes. Even in this model, however, the long-term interest rate unambiguously will fall in anticipation of the future deficit reduction, and the current real short-term rate will fall in response to a current deficit reduction.

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21. For example, suppose real exports and imports are initially unchanged after the domestic currency falls. The domestic price of exports will remain unchanged, but the domestic price of imports will rise with the depreciation of the home currency. Therefore, the nominal value of net exports will initially fall.

NUMERICAL RESULTS OF SIMULATION EXPERIMENTS

Basically, two approaches to assessing the relationship between deficits and interest rates appear in the literature. The single-equation approach investigates the properties of individual equations that relate a dependent variable--such as an interest rate--to explanatory variables--such as output, prices, money, and the deficit--that are posited to determine the dependent variable.[22] The simulation approach uses a macroeconomic model--a set of estimated equations that are posited to approximate the behavior and interrelationships of key economic variables--to determine how a change in the course of budget variables affects the course of interest rates.

The single-equation approach essentially tests whether deficits affect interest rates when all other factors affecting interest rates are statistically isolated. It uses statistical estimates of posited single-equation relationships to infer the probability that reducing the deficit reduces the interest rate, other things equal, as well as to make point estimates of the magnitude of any such relationship. A companion paper, Iden and Sturrock (1989), surveys the literature that conducts such studies. It concludes that, while most published studies show some relationship between deficits and interest rates, the results are too dispersed to yield decisive conclusions. This failure to establish a relationship may be due to technical problems that plague most of the studies--in particular, the fact that a single-equation approach is not well suited when the explanatory variables are not truly independent, or exogenous, themselves.[23]

The simulation approach is adopted here. By contrast to the single-equation approach, it indicates an estimate of the period-by-period response of the economy to a policy-induced deficit reduction when the interrelationships among all factors are, in principle, taken into account. This requires using a macroeconomic model to compare the simulated results of alternative policy actions. Typically the specification of the model implies that lower deficits lead to lower interest rates, although the extent of the reduction is determined by the statistical estimates, given such a specification. Many economists, however, feel that restricting estimates in this way is justified, especially in view of the indecisive nature and inherent problems of the single-equation studies. Unfortunately, statistical testing of alternative specifications, in the manner of single-equation studies, is usually not possible.

To provide some numerical evidence from macroeconometric systems on the effects of fiscal policy change on interest rates, CBO has performed simulations on four macro models and surveyed six other simulation studies. In addition, the

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22. Technically, a "single-equation" approach may refer to a method of estimating a set of simultaneous equations in a way that accounts for simultaneity, but not for any cross-equation correlation among equation errors. It is used here, however, simply to refer to separate estimation of individual equations taken by themselves.

23. A variable is exogenous in a regression equation when it is uncorrelated with the equation error. The deficit is not strictly exogenous because it is itself determined in part by other variables--and these include the interest rate because interest costs are part of the deficit.

results of a simulation project sponsored by the Brookings Institution that involved twelve models are reported.

CBO SIMULATIONS

CBO performed simulations on the following models: Data Resources, Inc. (DRI); FAIRMODEL developed by Ray Fair; Washington University Macroeconomic Model (WUMM) developed by Laurence Meyer and associates; and an updated version of the St. Louis model developed at the Federal Reserve Bank of St. Louis.[24] These models cannot necessarily be taken as representative of the full range of possible theoretical views and they do not provide unique representations of a given theoretical view. The models of DRI, Fair, and WUMM are structural and lie within a Keynesian, income-expenditure framework.[25] The St. Louis model is viewed as a quasi-reduced-form system and is monetarist in conception.

On each model, four simulations were performed that introduced similar fiscal shocks to the model baselines. The deficit shocks were introduced either as an exogenous decrease in federal government noncompensation purchases or as an increase in federal personal tax rates.[26] Each case represented a once-for-all static decline in the deficit of about 1.1 percent of baseline GNP. The static deficit decline is calculated assuming that all factors other than tax or expenditure rates remain unchanged, but the realized decline will differ because, as discussed in the theoretical section, other things will not remain unchanged. Each fiscal policy shock was introduced with alternative monetary assumptions: one held nonborrowed reserves (plus extended credit) to baseline levels; the other allowed money growth to rise enough to (approximately) return GNP to its baseline levels. The details underlying the model simulations are presented in Appendix I.

The monetary policies considered can be taken to represent polar extremes. Holding nonborrowed reserves at baseline levels implies that the results constitute a pure fiscal effect of the deficit shock because the monetary authority doesn't change its holding of federal debt. The resulting change in the interest rate, however, occurs not only because of an autonomous change in the deficit, but also because the fiscal shock causes output to fall below baseline levels.[27] Allowing money to vary in order to attempt to maintain GNP at its baseline levels acts to eliminate the indirect effect of output variation, but confounds the results by introducing a monetary shock in addition to the fiscal shock. Higher monetary growth will initially further lower the interest rate, providing the impetus for faster output (and price) growth in these models. While the exact response of the Federal

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24. References to these models are provided in Appendix I.

25. Appendix II discusses the distinction between structural and nonstructural models.

26. Only changes in the structural measure of expenditures were considered in the St. Louis model because it contains no tax variables.

27. Changes in other variables that affect the outcome also occur, but their effects are typically small compared to the direct and indirect effects of output changes.

Reserve to such a large fiscal shock cannot by predicted, it is nearly certain to lie between the two extremes considered here.

CBO Simulations: Nonborrowed Reserves Held to Baseline Values

As Tables 1, 2, and 3 show, the simulated effects of deficit reduction when nonborrowed reserves are held to baseline levels vary substantially across the models.[28]

Income-Expenditure Models. Unlike the St. Louis model, the Keynesian models exhibit an initial rise in the ex-post real short-term interest rate when purchases are reduced. Although the nominal short-term interest rate initially declines in these models, the inflation rate declines even more as output falls. The real rate does not, however, rise in the DRI and FAIR models when taxes are increased. This reflects the fact that output growth, and hence inflation, are reduced less by tax increases than by cuts in purchases in these models. The ex-post real short-term interest rate eventually falls in all the Keynesian model simulations.

The DRI and Fair models exhibit interest rate responses that, at least initially, are greater for an increase in taxes than for a decrease in purchases, even though their respective output responses are greater for a decrease in purchases than for an increase in taxes. This result occurs because real disposable income is the scale variable in the relevant real money demand functions in both models. Although output and before-tax income fall more in the respective purchases simulations than in the respective tax simulations, the tax increase also directly reduces disposable income. So disposable income and, hence, money demand initially fall more in the tax simulations than in the purchases simulations, putting greater downward pressure on the interest rate. In WUMM, total domestic output is the scale variable, so any direct effect from increased tax revenue is foreclosed.

Long-term rates eventually fall by about as much as short rates in FAIRMODEL and WUMM, but long-term rates respond more vigorously in the DRI model. This occurs because the DRI model, unlike the others, includes a liquidity-risk variable that depends on the deficit in the long-rate equation. This permits the deficit to affect long rates directly in the DRI formulation. Because the actual fall in the deficit is greater in the DRI model when taxes are raised than when purchases are reduced, the fall in the long-term rate relative to the short-term rate is greater in the DRI tax simulation than in the DRI purchases simulation.

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28. If it had been assumed that the Federal Reserve maintained money (M1) at baseline levels, interest rates in WUMM and FAIRMODEL would have fallen about 0.1 percentage points more than is shown in Tables 1 and 2. The responses of interest rates in the DRI model would have been roughly similar to those reported below for DRI simulations in which GNP is returned to baseline levels.

TABLE 1. CHANGES IN SHORT-TERM INTEREST RATES PER $50 BILLION STATIC DEFICIT REDUCTION: NONBORROWED RESERVES HELD TO BASELINE (Interest rate changes expressed in percentage points) [a]

	Year 1	Year 2	Year 3	Year 4	Year 5
Nominal Interest Rates					
Purchases Cut					
DRI	0.0	-0.3	-0.5	-0.7	-0.8
Fair	0.0	-0.1	-0.1	-0.1	-0.1
St. Louis	-0.1	-0.3	-0.2	-0.1	-0.1
WUMM	-0.4	-0.5	-0.5	-0.5	-0.5
Tax Increase					
DRI	-0.5	-0.9	-0.9	-0.9	-0.7
Fair	-0.1	-0.2	-0.2	-0.2	-0.2
WUMM	-0.1	-0.2	-0.3	-0.3	-0.3
Ex-Post Real Interest Rates [b]					
Purchases Cut					
DRI	0.1	0.1	0.0	-0.1	-0.3
Fair	0.2	0.1	0.0	0.0	-0.1
St. Louis	0.0	-0.1	0.0	0.1	0.1
WUMM	0.4	0.1	-0.1	-0.2	-0.3
Tax Increase					
DRI	-0.3	-0.6	-0.8	-0.7	-0.7
Fair	-0.1	-0.2	-0.2	-0.2	-0.2
WUMM	0.2	0.1	0.0	-0.1	-0.2

SOURCE: Congressional Budget Office.

a. The short-term rate is the 91-day Treasury bill rate except for the St. Louis model where a 3-month commercial paper rate is reported. The money stock (M1) was held at baseline levels in the simulation of the St. Louis model.

b. The ex-post real interest rate is defined here as the nominal interest rate minus next quarter's inflation rate of the GNP deflator.

TABLE 2. CHANGES IN NOMINAL LONG-TERM INTEREST RATES AND INFLATION RATES PER $50 BILLION STATIC DEFICIT REDUCTION: NONBORROWED RESERVES HELD TO BASELINE (Rate changes expressed in percentage points) [a]

	Year 1	Year 2	Year 3	Year 4	Year 5
Long-Term Interest Rate					
Purchases Cut					
DRI	-0.1	-0.4	-0.6	-0.7	-0.8
Fair	0.0	0.0	-0.1	-0.1	-0.1
St. Louis	0.0	0.0	-0.1	-0.1	-0.1
WUMM	-0.1	-0.4	-0.5	-0.5	-0.5
Tax Increase					
DRI	-0.5	-1.0	-1.2	-1.3	-1.3
Fair	0.0	-0.1	-0.2	-0.2	-0.2
WUMM	0.0	-0.2	-0.2	-0.3	-0.3
Inflation Rate					
Purchases Cut					
DRI	-0.0	-0.4	-0.4	-0.5	-0.4
Fair	-0.1	-0.2	-0.1	0.0	0.0
St. Louis	-0.1	-0.2	-0.2	-0.2	-0.2
WUMM	-0.7	-0.6	-0.4	-0.2	0.0
Tax Increase					
DRI	-0.2	-0.2	-0.1	0.0	0.0
Fair	0.0	0.0	0.0	0.0	0.0
WUMM	-0.3	-0.3	-0.3	-0.2	-0.1

SOURCE: Congressional Budget Office.

a. The long-term rate is the yield on seasoned Moody's AAA corporate bonds. The money stock (M1) was held at baseline levels in the simulation of the St. Louis model. Inflation rates represent growth in the GNP deflator over successive four-quarter intervals.

TABLE 3. OUTPUT AND PRICE RESPONSES TO CBO FISCAL EXPERIMENTS PER $50 BILLION STATIC DEFICIT REDUCTION: NONBORROWED RESERVES HELD TO BASELINE LEVELS (Percentage change from baseline) [a]

	Year 1	Year 2	Year 3	Year 4	Year 5
Nominal GNP					
Purchases Cut					
DRI	-1.5	-2.0	-2.0	-2.1	-2.3
FAIR	-1.6	-1.7	-1.4	-1.3	-1.1
St. Louis	-0.4	-0.7	-0.7	-0.7	-0.6
WUMM	-2.2	-2.5	-2.3	-2.1	-1.9
Tax Increase					
DRI	-1.0	-1.1	-0.4	-0.1	0.0
FAIR	0.0	-0.1	-0.1	-0.2	-0.2
WUMM	-0.8	-1.2	-1.3	-1.3	-1.2
GNP Deflator					
Purchases Cut					
DRI	0.0	-0.2	-0.6	-1.1	-1.5
FAIR	0.0	-0.2	-0.3	-0.4	-0.4
St. Louis	0.0	-0.2	-0.4	-0.5	-0.6
WUMM	-0.4	-1.1	-1.5	-1.7	-1.8
Tax Increase					
DRI	-0.1	-0.3	-0.5	-0.5	-0.5
FAIR	0.0	0.0	0.0	0.0	0.0
WUMM	-0.1	-0.5	-0.7	-0.9	-1.0

SOURCE: Congressional Budget Office.

a. The money stock (M1) was held at baseline levels in the simulation of the St. Louis model.

The St. Louis Model. In the St. Louis model, both short-term and long-term interest rates fall only slightly.[29] The small decline in the nominal short-term rate reflects its modeled dependence on real growth and inflation rates, whose movements tend to offset each other--the inflation rate falling below its baseline values, and the real growth rate rising above it baseline values.[30] Given a lower inflation rate and little eventual change in the nominal short-term rate, the realized real rate even rises above its baseline values by the end of the simulation period. The long-term rate slowly responds to the lower inflation rate.

Overall Effects on the Deficit. Because of feedback effects, the overall change in the deficit as a result of changes in budget policy is initially less than the static effect, although this difference tends to disappear over time (see Table 4). Each entry in Table 4 shows the simulated change in the federal government deficit (NIPA basis) as a percentage of the static deficit reduction--the reduction calculated by supposing that output, prices, and interest rates remain unchanged from the baselines when taxes or spending are changed. Because the deficit reduction leads to lower output and incomes, the simulated deficit reduction usually is initially less than the static reduction, especially when purchases are reduced. With lower interest rates, however, debt service costs are lower, and this effect grows over time, as Table 5 indicates.

The snowballing effect occurs both because debt is rolled over at lower interest rates and because lower interest costs reduce the accumulation of debt. The results are particularly sensitive to declines in the long-term interest rate--especially in the early years--because the calculations underlying Table 5 assume that 80 percent of new debt is financed by issuing long-term securities. As interest rates fall and output begins to recover, the simulated deficit reduction eventually approaches or surpasses the static reduction. In the FAIRMODEL, the tax multiplier is so small that, even in the first year, the decline in interest payments associated with the smaller deficit more than offsets the decline in revenues associated with lower output.

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29. The exact responses reported for the St. Louis model simulations may reflect, in part, reestimation and modification of the model by CBO. But the generally slight responses are characteristic of the model.

30. Nominal output growth initially falls, but returns to baseline after five quarters. Real output growth also initially falls because the inflation rate--which varies directly with past inflation and real output growth--responds sluggishly. Because the inflation rate initially falls and is modeled to depend on its past values, it remains below baseline. Therefore, with nominal output growth unchanged from baseline, real output growth must rise above baseline.

TABLE 4. SIMULATED CHANGES IN FEDERAL DEFICIT: NONBORROWED RESERVES HELD AT BASELINE LEVELS (Percent of static change)

	Year 1	Year 2	Year 3	Year 4	Year 5
Purchases Cut					
DRI	40.9	31.8	44.0	53.8	61.3
Fair	77.5	72.6	79.9	87.7	96.5
St. Louis	n.a.	n.a.	n.a.	n.a.	n.a.
WUMM	74.3	71.0	72.8	80.0	87.3
Tax Increase					
DRI	70.1	80.0	116.1	137.1	142.4
Fair	106.5	110.2	113.5	118.1	122.4
WUMM	86.4	80.3	83.0	89.7	97.2

SOURCE: Congressional Budget Office.

TABLE 5. CALCULATED CONTRIBUTION OF LOWER INTEREST RATES TO DEFICIT REDUCTION: NONBORROWED RESERVES HELD TO BASELINE LEVELS (Billions of dollars per $50 billion static deficit reduction) [a]

	Year 1	Year 2	Year 3	Year 4	Year 5
Purchases Cut					
DRI	0.1	1.8	5.1	9.0	13.1
Fair	0.0	0.3	0.7	1.2	1.7
St. Louis	0.3	1.1	1.5	1.7	2.1
WUMM	1.3	3.3	5.8	8.4	10.7
Tax Increase					
DRI	2.1	7.2	13.3	19.1	24.2
Fair	0.3	0.9	1.8	2.9	3.8
WUMM	0.3	1.1	2.5	4.0	5.3

SOURCE: Congressional Budget Office.

a. The table is constructed using the assumption underlying the rules of thumb that appear in CBO (1988), p. 63, in addition to the interest rate responses generated by the respective simulations. Because the rules of thumb may not agree with the relevant model specifications, the table entries may not reflect the deficit implications of lower interest rates contained in the respective models.

CBO Simulations: GNP Returned to Baseline Values

As Tables 6, 7, and 8 indicate, the relative rankings of interest rate responses across models change when monetary policy is assumed to return GNP to its baseline levels.[31]

Income-Expenditure Models. When purchases are reduced, FAIRMODEL shows the greatest interest rate response when GNP is returned to baseline values, rather than the weakest as it did when nonborrowed reserves were held to baseline levels. This occurs because relatively large changes in the interest rate are needed to change output in this model. On the other hand, when taxes are increased in FAIRMODEL, there is less difference in the interest rate response across the two monetary policy assumptions. This follows because the FAIRMODEL tax multiplier is relatively small, so monetary policy need not be so accommodative to maintain GNP. Since the inflation rate is little affected in any FAIRMODEL simulation--at least after the third year--declines in the real interest rate are roughly equal to declines in the nominal rate.

In the DRI model, the interest rate responses for each fiscal shock are usually at least as great when GNP is returned to baseline values as when nonborrowed reserves were held to baseline values. In particular, the interest rate response in the DRI simulation to a cut in purchases is much greater than when nonborrowed reserves were held to baseline levels. In the tax simulation, however, the two monetary policy assumptions generate similar interest rate responses after two years. This latter result simply reflects the fact that GNP had already approximately returned to its baseline levels in the fourth and fifth years of the tax simulation when nonborrowed reserves remained at baseline levels.

WUMM simulations controlling GNP display interest rate responses after three years that are slightly weaker than the analogous simulations controlling nonborrowed reserves. Two factors principally account for this apparent anomaly. First, compared to DRI and FAIRMODEL, it takes relatively small changes in the interest rate to change output in WUMM. Second, after the third year of the WUMM simulations in which nonborrowed reserves were held to baseline levels, most of the fall in output was accounted for by a lower price level, rather than by lower real output. So returning GNP to baseline levels after that period affects the price level more than real output. The money demand equation in WUMM is more sensitive to the price level than to real output, so higher interest rates than otherwise are required to clear the market. (The money demand equation in the DRI model also contains this feature, but the above anomaly does not arise because it takes larger changes in the interest rate to change output.)

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31. Because the deficit reductions considered were nominally denominated, GNP, rather than real GNP, was controlled. As discussed in Appendix I, GNP was returned to baseline levels by the second year of the WUMM and St. Louis model simulations, and by the third year of the DRI and FAIRMODEL simulations. Therefore, the comparative differences in interest rate responses are illustrative, but probably most meaningful in the fourth and fifth years of the simulations.

TABLE 6. CHANGES IN SHORT-TERM INTEREST RATES PER $50 BILLION STATIC DEFICIT REDUCTION: GNP RETURNED TO BASELINE (Interest rate changes expressed in percentage points) [a]

	Year 1	Year 2	Year 3	Year 4	Year 5
Nominal Interest Rates					
Purchases Cut					
DRI	-2.7	-1.3	-1.4	-1.6	-1.6
Fair	-4.2	-2.8	-3.0	-3.1	-3.1
St. Louis	0.0	0.0	0.0	0.0	0.0
WUMM	-1.4	-0.7	-0.5	-0.3	-0.2
Tax Increase					
DRI	-1.2	-0.8	-0.8	-0.8	-0.7
Fair	-0.2	-0.5	-0.6	-0.8	-0.9
WUMM	-0.6	-0.4	-0.4	-0.2	-0.1
Ex-Post Real Interest Rates [b]					
Purchases Cut					
DRI	-2.3	-1.2	-1.3	-1.5	-1.6
Fair	-4.0	-2.9	-3.1	-3.1	-3.1
St. Louis	0.0	0.0	0.0	0.0	0.0
WUMM	-1.2	-0.8	-0.5	-0.3	-0.2
Tax Increase					
DRI	-0.9	-0.7	-0.7	-0.7	-0.7
Fair	-0.2	-0.5	-0.7	-0.8	-0.9
WUMM	-0.5	-0.5	-0.4	-0.2	-0.1

SOURCE: Congressional Budget Office.

a. The short-term rate is the 91-day Treasury bill rate except for the St. Louis model where a 3-month commercial paper rate is reported. The money stock (M1) was held at baseline levels in the simulation of the St. Louis model.

b. The ex-post real interest rate is defined here as the nominal interest rate minus next quarter's inflation rate of the GNP deflator.

TABLE 7. CHANGES IN NOMINAL LONG-TERM INTEREST RATES AND INFLATION RATES PER $50 BILLION STATIC DEFICIT REDUCTION: GNP RETURNED TO BASELINE (Rate changes expressed in percentage points) [a]

	Year 1	Year 2	Year 3	Year 4	Year 5
Long-Term Interest Rate					
Purchases Cut					
DRI	-1.4	-1.6	-1.6	-1.9	-1.9
Fair	-1.6	-2.5	-2.7	-2.9	-3.0
St. Louis	0.0	0.0	0.0	0.0	0.0
WUMM	-0.7	-0.5	-0.5	-0.5	-0.5
Tax Increase					
DRI	-0.8	-1.1	-1.2	-1.3	-1.3
Fair	-0.1	-0.3	-0.4	-0.6	-0.7
WUMM	-0.3	-0.3	-0.3	-0.3	-0.3
Inflation Rate					
Purchases Cut					
DRI	-0.2	-0.2	0.0	-0.1	0.0
FAIR	0.0	0.0	0.1	0.0	0.0
St. Louis	0.0	0.0	0.0	0.0	0.0
WUMM	-0.2	0.2	0.0	0.0	0.0
Tax Increase					
DRI	-0.2	-0.2	0.0	0.0	0.0
FAIR	0.0	0.0	0.0	0.0	0.0
WUMM	-0.1	0.1	0.0	0.0	0.0

SOURCE: Congressional Budget Office.

a. The long-term rate is the yield on seasoned Moody's AAA corporate bonds. The money stock (M1) was held at baseline levels in the simulation of the St. Louis model. Inflation rates represent growth in the GNP deflator over successive four-quarter intervals.

TABLE 8. OUTPUT AND PRICE RESPONSES TO CBO FISCAL EXPERIMENTS PER $50 BILLION STATIC DEFICIT REDUCTION: GNP RETURNED TO BASELINE LEVELS
(Percentage change from baseline)

	Year 1	Year 2	Year 3	Year 4	Year 5
Nominal GNP					
Purchases Cut					
DRI	-1.3	-0.8	0.1	0.0	-0.1
FAIR	-1.2	-0.3	0.1	0.0	0.0
St. Louis	-0.1	0.0	0.0	0.0	0.0
WUMM	-0.7	0.0	0.0	0.0	0.0
Tax Increase					
DRI	-1.0	-0.9	-0.1	0.1	0.0
FAIR	0.0	0.0	0.0	0.0	0.0
WUMM	-0.2	0.0	0.0	0.0	0.0
GNP Deflator					
Purchases Cut					
DRI	-0.1	-0.4	-0.4	-0.5	-0.5
FAIR	0.0	-0.1	0.0	0.0	0.1
St. Louis	0.0	0.0	0.0	0.0	0.0
WUMM	-0.2	-0.1	-0.1	-0.1	-0.1
Tax Increase					
DRI	-0.1	-0.3	-0.4	-0.4	-0.4
FAIR0	0.0	0.0	0.0	0.0	0.0
WUMM	-0.1	0.0	0.0	0.0	0.0

SOURCE: Congressional Budget Office.

Inflation rates in the DRI and WUMM simulations in which GNP was controlled are noticeably higher than in the analogous simulations controlling nonborrowed reserves--sometimes becoming higher than inflation rates on the baseline. This accounts for the fact that the declines in the ex-post real rates are roughly as great as the declines in the nominal rates in those models when GNP is controlled.

The St. Louis Model. In the St. Louis model, unlike the Keynesian models, there are virtually no changes in interest rates. This occurs because nominal output can be closely controlled virtually from the beginning of the simulation. Given the relationships among output, the price level, and interest rates discussed earlier, this implies that there is virtually no change in inflation or real output growth, and, hence, no change in any interest rates.

Overall Effects on the Deficit. The simulated changes in the deficit are typically much greater when GNP, rather than the level of nonborrowed reserves, is controlled (see Table 9). In all cases in which GNP was returned to baseline values, the simulated deficit reduction is greater than the static reduction by the third year. This occurs because, except in the case of DRI tax simulations, incomes remain higher and interest rates fall lower when GNP is returned to baseline values. By the fourth year of the FAIRMODEL tax simulation in which GNP is returned to baseline levels, the calculated contribution of lower interest rates to deficit reduction is by itself greater than the static reduction (see Table 10). In general, the entries of Table 10 are straightforward reflections of the interest rate responses already discussed. The purchases simulations of DRI and FAIR with GNP returned to the baseline differ most from their analogues that held nonborrowed reserves to baseline values. Neither of the WUMM simulations differs substantially from its analogous simulation holding nonborrowed reserves to baseline values. As noted, interest rates do not change from baseline values in the St. Louis model when GNP is returned to baseline values, so there is no additional contribution from lower interest rates to deficit reduction.

CBO Simulations: International Linkages

International linkages are nonexistent or relatively primitive in the models that CBO simulated. The St. Louis model represents a closed economy. The only international sector variable that FAIRMODEL allows to respond endogenously to changed conditions is U.S. real imports, which depend on the level of domestic activity in the model. In addition to U.S. imports, the DRI model and WUMM also allow for endogenous movements in foreign output, prices, and interest rates. These variables in turn help to determine the exchange rate and foreign demand for U.S. exports. The modeling of foreign output, prices, and interest rates is rudimentary, however--depending simply on movements in U.S. output, prices, and interest rates, respectively.

These linkages, at least as specified, appear to be of little importance to interest rate responses in these models. The linkages can be severed in WUMM and the DRI model by holding exports, the exchange rate, and the foreign levels of output, interest rates, and prices to their baseline levels. Doing so when deficits are reduced

TABLE 9. SIMULATED CHANGES IN FEDERAL DEFICIT: GNP RETURNED TO BASELINE LEVELS (Percent of static change)

	Year 1	Year 2	Year 3	Year 4	Year 5
Purchases Cut					
DRI	75.9	110.6	146.8	155.9	158.6
Fair	140.8	231.4	232.0	235.6	273.1
St. Louis	n.a.	n.a.	n.a.	n.a.	n.a.
WUMM	102.5	128.7	132.9	139.1	144.1
Tax Increase					
DRI	78.6	94.9	128.6	141.3	139.7
Fair	101.1	125.0	125.8	136.6	180.4
WUMM	105.6	118.5	123.6	130.7	133.8

SOURCE: Congressional Budget Office.

TABLE 10. CALCULATED CONTRIBUTION OF LOWER INTEREST RATES TO DEFICIT REDUCTION: GNP RETURNED TO BASELINE LEVELS (Billions of dollars per $50 billion static deficit reduction) [a]

	Year 1	Year 2	Year 3	Year 4	Year 5
Purchases Cut					
DRI	9.5	18.2	25.0	33.1	42.2
Fair	14.0	28.2	41.0	55.0	69.2
St. Louis	0.0	0.0	0.0	0.0	0.0
WUMM	4.9	8.9	10.4	11.5	13.2
Tax Increase					
DRI	4.5	10.0	15.2	20.6	26.0
Fair	0.7	2.7	5.3	8.5	12.3
WUMM	2.1	4.2	5.7	6.5	7.3

SOURCE: Congressional Budget Office.

a. The table is constructed using the assumption underlying the rules of thumb that appear in CBO (1988), p. 63, in addition to the interest rate responses generated by the respective simulations. Because the rules of thumb may not agree with the relevant model specifications, the table entries may not reflect the deficit implications of lower interest rates contained in the respective models.

as above and nonborrowed reserves are held to baseline levels reduces the (absolute) interest rate response in these models by less than 0.1 percentage point.

OTHER SIMULATION STUDIES

Other authors have reported interest rate responses that they obtained from simulated deficit reductions. These include: Cohen-Clark (1984), using the MIT-PENN-SSRC Model (MPS) and the Multi-Country Model (MCM), both maintained at the Federal Reserve Board; Edison-Marquez-Tryon (1987), using the MCM; Fair (1984) using FAIRMODEL; Meyer (1983), using WUMM; and Sinai-Rathjens (1983), using the DRI model. As Table 11 shows, the responses are uniformly greater than those obtained by CBO when nonborrowed reserves were held to baseline levels. Sinai-Rathjens and Meyer report even greater interest rate responses in the short-term and long-term rates, respectively, than CBO obtained in simulating later versions of the models those authors used. Note also that MCM displayed much less interest rate sensitivity in the Edison-Marquez-Tryon experiment reducing purchases than it did in the Cohen-Clark experiment increasing taxes, even though a reduction in purchases would ordinarily be expected to affect interest rates more than a comparable increase in taxes.

Doan, Litterman, and Sims (1984) simulated a vector autoregressive model (VAR) assuming that the deficit was eliminated in 18 months.[32] They report only very small effects on the interest rate. The 91-day Treasury bill rate initially falls about 25 basis points per $50 billion cut in the deficit, then hovers about zero change thereafter. As discussed in Appendix II, however, the VAR approach emphasizes the incorporation of as much empirical correlation in the estimates of the system as possible without recourse to restrictions implied by theory. Therefore the results admit the interpretation that they represent, on the basis of historical experience, only the most likely course of events associated with having the deficit go to zero (for example, fortuitously higher GNP growth), not necessarily the response to a policy-induced deficit cut.

The authors of the various studies just mentioned did not all use the same monetary and fiscal policy assumptions, and this could help explain why they arrived at interest rate responses that differ from those obtained by CBO. But such differences in simulation results can arise for other reasons as well. First, the authors were not using the same versions of the various models as used by CBO. Simulation properties of models can change when they are updated, either because individual equations in the model are respecified to contain sets of variables different from before, or simply because the newer data used in reestimating the model imply different responses. Second, besides using model versions different from those used by CBO, some of the authors modified their models in conducting the experiment. Sinai-Rathjens and Fair, in particular, introduced interest rate reaction functions that were directly affected by expected future actual deficits. Finally the responses of a given model can be affected by the conditions of the

32. See Appendix II for a discussion of the VAR approach.

TABLE 11. OTHER PUBLISHED SIMULATION RESULTS (Changes in interest rates normalized by $50 billion static reduction in federal deficit)

Study	Rate	Interest Rate Effects (In percentage points) Year 1	Year 2	Year 3	Year 4
Cohen-Clark, MPS [a]	91-day T-bill	-1.6	-1.8	-1.4	-1.5
Cohen-Clark, MCM	91-day T-bill	-3.5	-3.7	-2.6	-2.2
Edison-Marguez-Tryon [b]	91-day T-bill	-2.1	-2.3	-2.2	-2.3
Fair [c]	91-day T-bill	-1.3	-1.8	-1.4	n.a.
	AAA Corporate Bonds [d]	-0.5	-1.1	-1.2	n.a.
Meyer [e]	AAA Corporate Bonds	-1.1	-1.2	n.a	n.a
Sinai-Rathjens [f]	91-day T-bill	-2.1	-1.6	-2.0	-2.2
	AAA Corporate Bonds [g]	-1.0	-1.0	-1.0	-0.9

a. Cohen-Clark simulated a 10 percent reduction in personal tax rates over the period 1982:III to 1986:IV under the assumption that M1 is held to baseline levels. The reported interest rate effects were taken at the end of successive four-quarter intervals. The simulated changes in interest rates were normalized by the simulated changes in federal personal tax revenues as reported for the MPS simulation.

b. Edison-Marguez-Tryon simulated an increase in real government purchases equal to 1 percent of baseline real GNP beginning in 1983:I and assuming M1 is held to baseline levels.

c. Fair simulated a real federal spending increase amounting to 1 percent of real GNP over the period 1970-72. He estimated an interest rate reaction function that included expected future federal deficits and appended this equation to his macro model. The results reported here are taken from Case 2 of Fair (1984), Table 2, p. 14.

d. Seasoned issues.

e. Meyer simulated the effects of spending cuts of $31 billion in FY 1985 and $50 billion in FY 86. The results reported here are five- and nine-quarter changes in bond rates.

f. Sinai-Rathjens simulated a $100 billion deficit reduction by cutting expenditure and raising taxes proportionately on a modified version of the DRI model. The effects reported here are for their scenario holding M1 to baseline levels.

g. New issues.

period over which it is simulated.[33] In particular, the money demand equations in WUMM, MCM, and the MPS model all imply proportional relationships among money, real output, the price level, and the interest rate. But a given proportional change in the interest rate implies a greater absolute change when interest rates are high rather than low. Except during Fair's simulation period, interest rates were much higher, and typically were projected to remain so, during the period of these studies than during the period of CBO's simulations.

THE BROOKINGS PROJECT

More recently the Brookings Institution sponsored a study reported in Bryant and others (1988) that examines the simulation properties of 12 models.[34] The project is noteworthy because all the models contain extensive international detail and were simulated under (nearly) identical circumstances.

Model Description and Simulation Design

The models included in the study were:

DRI: The Data Resources, Inc., International Model (which contains as a submodel an earlier version, US85B, of the U.S. model used by CBO for this study);

EEC: The COMPACT model developed by the staff of the Commission of the European Economic Community in Brussels;

EPA: The World Econometric Model of the Japanese Economic Planning Agency developed by the Economic Research Institute;

LINK: The Project LINK system, which has headquarters at the University of Pennsylvania, imposes a consistent solution on 79 separate national and regional models;

LIVERPOOL: The Liverpool model developed by Patrick Minford and his associates at Liverpool University;

MCM: The Multicountry Model developed by the staff of the U.S. Federal Reserve Board;

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33. All the structural models considered are nonlinear, which implies that the response to a given policy change can depend on the current state of the economy when the policy is initiated. For instance, Keynesian models are likely to display smaller real output and larger price responses to a deficit reduction when the economy is near full employment than when there is considerable unemployment. Even for given initial conditions, a given policy change need not have twice the effect of a change half its size. Also, the magnitude of the response to a given increase in the deficit need not be the same as to that of an equal decrease of the same type. In many cases, however, models can be considered roughly linear in proportions. The models also contain lagged variables so that the responses depend on the immediate history of the economy as well as its current state.

34. The following discussion of the models and simulation design relies heavily on Bryant, Holtham, and Hooper (1988).

MINIMOD: The MINIMOD model developed by Richard Haas and Paul Masson at the International Monetary Fund;

MSG: The McKibbin-Sachs Global model developed by Warwick McKibbin and Jeffrey Sachs at Harvard University;

OECD: The INTERLINK model system developed by the Economics and Statistics Department of the Organization for Economic Cooperation and Development;

TAYLOR: The Taylor model developed by John Taylor and associates at Stanford University;

VAR: The Minnesota World VAR model developed by Christopher Sims and Robert Litterman at the University of Minnesota and the Federal Reserve Bank of Minneapolis;

WEFA: The world model of the Wharton Econometric Forecasting Associates.

Other than VAR, all are structural models. The LINK and DRI systems impose mutually consistent solutions on groups of preexisting national or regional models, but all the other models were initially constructed as international in scope. MINIMOD and MSG were constructed by using coefficient estimates published in the literature, but all other models were estimated by their builders.

The LIVERPOOL, MINIMOD, MSG, and TAYLOR models impose rational, or forward-looking, expectations processes, especially in determining prices and interest rates. This implies that, at any time, the future values of variables that the model posits agents to expect are the same as the model would predict. The LIVERPOOL and TAYLOR models imposed such restrictions in the process of estimating the models. The remaining structural models specify expectations processes as adaptive, or backward-looking. In this case, expectations of future values of variables are typically represented as depending on their recent history, and these expected values are generally not those that the model would predict.

To the extent feasible, identical baselines were constructed for each model in the Brookings study. Each simulation began in 1985:I and reduced real U.S. government purchases by 1 percent of real GNP from baseline values. The reductions were distributed across defense and nondefense purchases according to their baseline proportions. It was supposed that the reduction was unanticipated, but, once initiated, economic agents expected it to be permanent. The Federal Reserve and foreign central banks were assumed to hold respective national monetary aggregates (M1 in the U.S. case) to baseline levels.[35]

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35. Results of a similar experiment in which foreign central banks were assumed to hold foreign interest rates to their baseline levels did not substantially change U.S. interest rate responses.

Results

As with the models that CBO simulated, there is a wide range of results from the Brookings experiment (see Tables 12-15).[36] The average interest rate response is greater than that shown in the simulations CBO conducted, and for each year of the simulations the mean absolute deviation (MAD)[37] of interest rate responses is about one-half the size of the (absolute) average interest rate response. The normalized interest rate response of most models roughly stabilizes after the first year. There is at best a weak association between the interest rate and real output responses among models--high interest rate responses tending to be associated with high real output responses (see Figure 1).

There does appear to be some association between the interest rate responses of the various models and the theoretical structures that underlie them. Of the rational expectations models, only MSG, which displays a rising response in the short-term rate, generates an above-average response after five years. The two models that were estimated with rational expectations restrictions, the LIVERPOOL and TAYLOR models, both show relatively low interest rate responses, but the full response occurs immediately. Of the models that specify adaptive expectations, only the LINK system implies an interest rate response substantially below average. The EPA shows the largest response, and one that grows over the entire period. The VAR shows very little response in interest rates, but the policy implications of this representation are not clear-cut.

The DRI simulation displays a short-term interest rate response after five years about 130 basis points greater than that obtained by CBO using a later version of the U.S. model. Three reasons may account for this difference. First, the DRI simulation for the Brookings project held money to baseline values, whereas the CBO simulation held nonborrowed reserves to baseline levels. Second, the DRI simulation for the Brookings project reduced purchases across the board, while the CBO simulation reduced only noncompensation purchases.[38] Third, the two versions of the model use different methods to reconcile discrepancies between product and income. The more recent version (US86B) treats corporate profits as a residual whereas the earlier version (US85B) allocated any discrepancies between the income and product accounts across all categories of income. Using the earlier method, reconciliation of income and product discrepancies affects real disposable income of households, which appears in the equation for demand deposits. With lower

36. The results have been normalized to provide comparability with the results of the CBO simulations. The normalization factor used for each model represents the share of 1985 GNP that corresponds to the share of 1987:III GNP that $50 billion represents.

37. The MAD is a measure of dispersion which indicates, on average, the absolute amount by which an element of a sample differs from the sample average.

38. Reducing compensation directly affects household disposable income and, as explained earlier, this puts further downward pressure on the interest rate because disposable income is the scale variable in the DRI demand for money.

TABLE 12. CHANGES IN SHORT-TERM INTEREST RATES PER $50 BILLION STATIC REDUCTION OF U.S. GOVERNMENT PURCHASES IMPLIED BY BROOKINGS PROJECT: M1 AND FOREIGN MONETARY AGGREGATES HELD TO BASELINE
(Interest rate changes expressed in percentage points)

	Year 1	Year 2	Year 3	Year 4	Year 5
Nominal Interest Rates					
DRI	-0.8	-1.7	-1.8	-2.0	-2.1
EEC	-1.1	-1.6	-1.6	-1.6	-1.6
EPA	-1.7	-2.3	-2.9	-3.4	-4.1
LINK	-0.1	-0.2	-0.3	-0.4	-0.5
LIVERPOOL	-0.3	-0.4	-0.4	-0.4	-0.4
MCM	-1.1	-1.8	-1.9	-2.0	-2.1
MINIMOD	-1.0	-1.1	-1.3	-1.4	-1.4
MSG	-0.8	-0.9	-1.4	-1.8	-2.2
OECD	-1.1	-1.8	-1.7	-1.7	-1.9
TAYLOR	-0.4	-0.3	-0.3	-0.3	-0.3
VAR	-0.1	-0.1	-0.1	0.0	0.0
WEFA	-1.1	-1.1	-1.3	-1.4	-1.4
AVERAGE	-0.8	-1.1	-1.2	-1.4	-1.5
MAD	0.4	0.6	0.7	0.7	0.8
Ex-Post Real Interest Rates [a]					
DRI	-0.4	-1.3	-1.3	-1.6	-1.7
EEC	-0.9	-1.4	-1.1	-1.4	-1.5
EPA	-0.9	-1.6	-2.3	-2.8	-3.4
LINK	0.1	0.1	0.2	-0.1	-0.2
LIVERPOOL	-0.2	-0.3	-0.4	-0.4	-0.4
MCM	-1.0	-1.2	-1.5	-1.6	-1.6
MINIMOD	-0.8	-0.8	-0.9	-1.0	-1.0
MSG	-0.8	-0.8	-1.2	-1.4	-1.8
OECD	-0.9	-1.2	-1.2	-1.3	-1.5
TAYLOR	-0.2	0.0	0.0	-0.2	-0.2
VAR	-0.4	-0.7	-0.2	0.1	0.1
WEFA	-1.2	-0.6	-1.1	-1.4	-1.4
AVERAGE	-0.6	-0.8	-0.9	-1.1	-1.2
MAD	0.3	0.4	0.5	0.6	0.7

SOURCE: Adapted by Congressional Budget Office from Bryant, Ralph C., and others, *Empirical Macroeconomics for Interdependent Economics: Supplemental Volume* (Washington, D.C.: The Brookings Institution, 1988) Part III: "Detailed Tables for Simulation Results," pp. 132, 134, 148, 150, 164, 166, 180, 182, 198, 200, 214, 216, 232, 234, 250,252, 268, 270. Reported values were normalized by CBO as explained in footnote 37.

a. The ex-post real interest rate is defined here as the nominal interest rate less the current year's inflation rate of the GNP deflator.

TABLE 13. CHANGES IN NOMINAL LONG-TERM INTEREST RATES PER $50 BILLION STATIC REDUCTION OF U.S.GOVERNMENT PURCHASES IMPLIED BY BROOKINGS PROJECT: M1 AND FOREIGN MONETARY AGGREGATES HELD TO BASELINE (Interest rate changes expressed in percentage points)

	Year 1	Year 2	Year 3	Year 4	Year 5
DRI	-0.6	-1.1	-1.4	-1.6	-1.6
EEC	-0.6	-1.0	-1.2	-1.2	-1.3
EPA	-0.6	-1.2	-1.9	-2.6	-3.2
LINK	-0.1	-0.2	-0.4	-0.4	-0.6
LIVERPOOL	-0.3	-0.3	-0.3	-0.2	-0.2
MCM	-0.3	-0.9	-1.4	-1.6	-1.6
MINIMOD	-0.1	-0.1	-0.2	-0.2	-0.2
MSG	-2.9	-2.9	-2.9	-2.7	-2.6
OECD	-0.3	-0.8	-1.2	-1.4	-1.5
TAYLOR	-0.4	-0.4	-0.4	-0.4	-0.4
VAR	n.a.	n.a.	n.a.	n.a.	n.a.
WEFA	-0.6	-0.9	-1.2	-1.5	-1.6
AVERAGE	-0.6	-0.9	-1.1	-1.2	-1.3
MAD	0.4	0.5	0.6	0.7	0.7

SOURCE: Adapted by Congressional Budget Office from Bryant, Ralph C., and others, *Empirical Macroeconomics for Interdependent Economics: Supplemental Volume* (Washington, D.C.: The Brookings Institution, 1988) Part III: "Detailed Tables for Simulation Results," pp. 132, 134, 148, 150, 164, 166, 180, 182, 198, 200, 214, 216, 232, 234, 250, 252, 268, 270. Reported values were normalized by CBO as explained in footnote 37.

TABLE 14. INFLATION RESPONSES PER $50 BILLION STATIC REDUCTION IN U.S. GOVERNMENT PURCHASES IMPLIED BY BROOKINGS PROJECT: M1 AND FOREIGN MONETARY AGGREGATES HELD TO BASELINE (Changes in annual percentage rates)

	Year 1	Year 2	Year 3	Year 4	Year 5
DRI	-0.3	-0.4	-0.5	-0.4	-0.4
EEC	-0.2	-0.2	-0.6	-0.2	-0.1
EPA	-0.8	-0.7	-0.6	-0.5	-0.7
LINK	-0.2	-0.3	-0.5	-0.4	-0.3
LIVERPOOL	-0.1	-0.1	0.0	-0.1	0.0
MCM	-0.1	-0.5	-0.5	-0.4	-0.4
MINIMOD	-0.2	-0.3	-0.4	-0.3	-0.4
MSG	0.0	-0.1	-0.2	-0.4	-0.4
OECD	-0.2	-0.5	-0.5	-0.4	-0.3
TAYLOR	-0.2	-0.3	-0.3	0.0	-0.1
VAR	0.3	0.6	0.1	-0.1	-0.1
WEFA	0.1	-0.5	-0.3	0.0	0.1
AVERAGE	-0.2	-0.3	-0.3	-0.3	-0.3
MAD	0.2	0.2	0.2	0.2	0.2

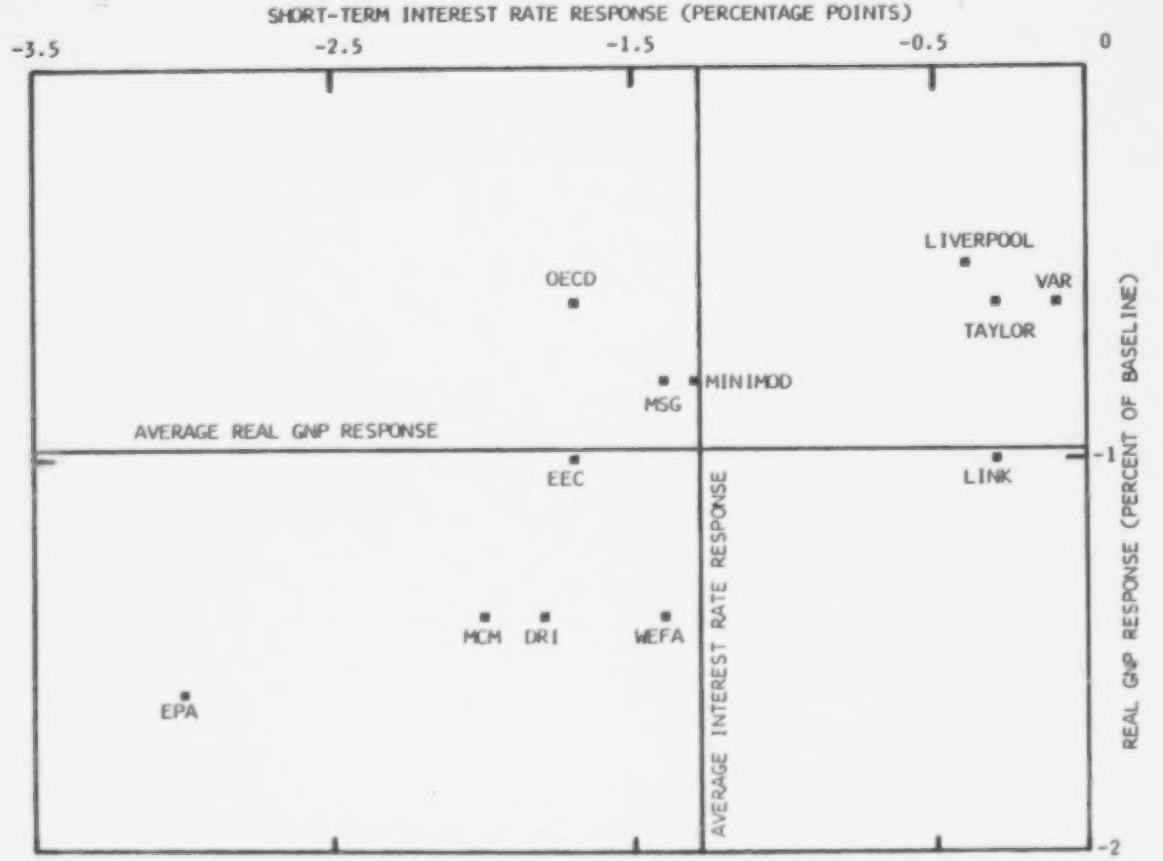
SOURCE: Adapted by Congressional Budget Office from Bryant, Ralph C., and others, *Empirical Macroeconomics for Interdependent Economics: Supplemental Volume* (Washington, D.C.: The Brookings Institution, 1988) Part III: "Detailed Tables for Simulation Results", pp. 132, 134, 148, 150, 164, 166, 180, 182, 198, 200, 214, 216, 232, 234, 250, 252, 268, 270. Reported values were normalized by CBO as explained in footnote 37.

TABLE 15. OUTPUT AND PRICE RESPONSES PER $50 BILLION STATIC REDUCTION IN U.S. GOVERNMENT PURCHASES IMPLIED BY BROOKINGS PROJECT: M1 AND FOREIGN MONETARY AGGREGATES HELD TO BASELINE (Percentage change from baseline)

	Year 1	Year 2	Year 3	Year 4	Year 5
			Nominal GNP		
DRI	-2.5	-2.9	-2.5	-2.5	-2.7
EEC	-1.7	-1.8	-1.9	-1.9	-1.8
EPA	-2.5	-3.2	-3.6	-4.0	-4.5
LINK	-1.5	-1.8	-1.9	-1.9	-2.0
LIVERPOOL	-0.8	-0.7	-0.8	-0.7	-0.7
MCM	-1.9	-2.5	-2.4	-2.4	-2.3
MINIMOD	-1.4	-1.6	-1.7	-1.7	-1.8
MSG	-0.9	-0.9	-1.1	-1.3	-1.7
OECD	-1.9	-1.9	-1.8	-2.0	-2.1
TAYLOR	-2.0	-1.1	-1.4	-1.5	-1.5
VAR	0.3	0.6	0.4	0.4	0.3
WEFA	-1.8	-1.9	-2.0	-2.0	-1.8
AVERAGE	-1.5	-1.6	-1.7	-1.8	-1.9
MAD	0.6	0.7	0.7	0.7	0.7
			GNP Deflator		
DRI	-0.3	-0.7	-1.2	-1.6	-2.0
EEC	-0.2	-0.4	-1.0	-1.2	-1.3
EPA	-0.8	-1.5	-2.0	-2.6	-3.2
LINK	-0.2	-0.5	-1.0	-1.3	-1.6
LIVERPOOL	-0.1	-0.2	-0.2	-0.3	-0.2
MCM	-0.1	-0.6	-1.1	-1.5	-1.9
MINIMOD	-0.2	-0.5	-0.9	-1.2	-1.5
MSG	0.0	-0.1	-0.3	-0.7	-1.1
OECD	-0.2	-0.7	-1.2	-1.6	-1.9
TAYLOR	-0.2	-0.5	-0.8	-0.8	-0.9
VAR	0.30	0.9	1.1	1.0	0.9
WEFA	0.1	-0.4	-0.7	-0.7	-0.7
AVERAGE	-0.2	-0.4	-0.8	-1.0	-1.3
MAD	0.2	0.3	0.5	0.6	0.7

SOURCE: Adapted by Congressional Budget Office from Bryant, Ralph C., and others, *Empirical Macroeconomics for Interdependent Economics: Supplemental Volume* (Washington, D.C.: The Brookings Institution, 1988) Part III: "Detailed Tables for Simulation Results," pp. 132, 134, 148, 150, 164, 166, 180, 182, 198, 200, 214, 216, 232, 234, 250, 252, 268, 270. Reported values were normalized by CBO as explained in footnote 37.

FIGURE 1. INTEREST RATE AND REAL GNP RESPONSES IN THIRD YEAR OF BROOKINGS PROJECT SIMULATIONS



SOURCES: Congressional Budget Office, Bryant, Ralph C. and others, eds., *Empirical Macroeconomics for Interdependent Economies: Supplemental Volume* (Washington, D.C.: The Brookings Institution, 1988), Part III: "Detailed Tables for Simulation Results," pp. 132, 134, 146, 148, 164, 166, 180, 182, 198, 200, 214, 216, 232, 234, 252, 254, 268, 270, 286, 288, 304, 306, 322, and 324.

disposable income using the earlier method, money demand is lower, reducing pressure on the interest rate.[39]

Responses in the realized real interest rate differed from those obtained by CBO. Only the LINK system in these simulations showed a first-year rise in the realized real short-term interest rate, whereas all the structural models that CBO simulated showed a rise when purchases were cut. In the LINK simulation, however, this persists for three years. The VAR and WEFA simulations initially display a greater response in the real short-term rate than in the nominal short-term rate. This results from an apparently perverse (with respect to the theoretical models discussed earlier) increase in the inflation rate occasioned by the cut in purchases. But the VAR is an atheoretical representation and the result admits an interpretation not directly associated with policy: because appropriations are often made in terms of current dollars, an increase in inflation would of itself lead to reduced real purchases.[40] Inflation initially rises in the WEFA simulation because the relevant price equation contains a term that reflects unit labor costs. Such costs typically rise as output falls--in this case by enough to cause inflation to rise above its baseline value.

The simulations reported by Brookings also display interesting responses in the yield curves of various models. Among the models with adaptive expectations, only the LINK system initially shows as much response in the long-term rate as in the short-term rate. Among the rational expectations models, the yield curve is initially unchanged in the TAYLOR and LIVERPOOL models, becomes much flatter in MSG, and much steeper in MINIMOD. The yield curve then steepens throughout the MSG simulation as the (absolute) long-term response declines, and the (absolute) short-term response rises. After five years, the LINK system and MSG, TAYLOR, and WEFA (but not DRI) simulations all display a flattening of the yield curve. This is most pronounced in MSG. Over the five-year period in the MSG simulation, the average normalized fall in the long-term rate is more than 1.3 percentage points greater than the average normalized fall in the short-term rate. On the other hand, the MINIMOD simulation shows the most steepening in the yield curve after five years.

Overall Effects on the Deficit

On average, the simulated deficit reduction is little different from the static reduction by the fifth year, but the results vary substantially (see Table 16). The simulated change in the deficit generated by the VAR falls to an especially low value. This occurs largely because the VAR model, based on historical experience, generates a decline in revenues associated with the decline in purchases. The

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39. This explanation was offered by Nigel Gault of DRI in a personal communication. The difference does not arise from gross differences in simulation properties of the two model versions. The form and parameters of the demand deposit equation are essentially unchanged between the two versions, and price and output responses are similar in the two simulations.

40. The result may also arise from an error in specifying the policy shock that Sims (1988) reports in footnote 9.

TABLE 16. SIMULATED CHANGE IN DEFICIT AS SHARE OF STATIC REDUCTION REPORTED BY BROOKINGS PROJECT (Percent)

	Year 1	Year 2	Year 3	Year 4	Year 5
DRI	21.8	40.7	89.5	121.5	138.2
EEC	83.3	76.5	88.6	63.5	50.7
EPA	30.1	26.4	58.9	97.0	136.3
LINK	49.4	38.5	38.6	45.3	56.8
LIVERPOOL	97.8	99.2	103.2	106.5	109.8
MCM	38.1	32.1	59.9	99.6	118.8
MINIMOD	54.4	52.8	58.5	63.8	68.7
MSG	75.7	81.1	94.4	109.3	127.3
OECD	75.1	82.7	121.0	164.4	208.3
TAYLOR	n.a	n.a	n.a	n.a	n.a
VAR	31.4	19.0	13.6	10.9	9.2
WEFA	41.5	43.4	40.5	40.2	38.8
AVERAGE	54.4	53.9	69.7	83.8	96.6
MAD	20.8	22.6	26.9	35.5	47.1

NOTE: n.a. = not applicable.

SOURCE: Adapted by Congressional Budget Office from Bryant, Ralph C., and others, Empirical Macroeconomics for Interdependent Economics: Supplemental Volume (Washington, D.C.: The Brookings Institution, 1988) Part III: "Detailed Tables for Simulation Results," pp. 132, 134, 148, 150, 164, 166, 180, 182, 198, 200, 214, 216, 232, 234, 250, 252, 268, 270. Reported values were normalized by CBO as explained in footnote 37.

WEFA, LINK, and EEC models also display relatively low or declining simulated deficit reductions. For the LINK system, this is consistent with the fact that interest rates do not fall enough to contribute substantially to deficit reduction. In the WEFA and EEC simulations, on the other hand, the behavior of neither output nor interest rates is substantially different from the norm. Similarly, OECD displays a substantially greater deficit reduction than the other models even though its interest rate and GNP responses are not substantially different from the average.

The Brookings simulations suggest that by the fifth year, lower interest rates, on average, would independently contribute to lower deficits by an amount equal to about one-half of the static reduction (see Table 17). This is higher than the fifth-year interest rate contribution reported for all of the simulations conducted by CBO except the DRI and FAIRMODEL purchases simulations which returned GNP to baseline levels. The short-term interest rate falls more in the EPA simulation than in the MSG, and the long-term interest rate eventually falls more in the EPA simulation. Nevertheless, lower interest rates contribute more to deficit reduction in the MSG simulation because, as discussed earlier, an early fall in the long-term rate weighs more heavily in the calculations.

CONCLUSIONS

The simulation results suggest that the response of the interest rate to a federal deficit reduction could be substantial. For example, for the models participating in the Brookings project, the average response of interest rates--real and nominal, short-term and long-term--was over one percentage point per $50 billion in the fifth year even if the most extreme response (EPA model) is omitted. The responses would be even greater if monetary policy were more accommodative.

Nevertheless, as with the single-equation studies considered by the companion paper to this study, Iden and Sturrock (1989), there is a considerable dispersion of results. Relatively small interest rate responses occur in some models--especially the nonstructural models (VAR and St. Louis) and the (estimated) rational expectations models (TAYLOR and LIVERPOOL), but also in some structural models (WUMM, LINK, and sometimes FAIRMODEL). Further, as was seen in a number of cases, these results can be strongly influenced by many factors--sometimes seemingly arbitrary or innocuous ones. The results can depend particularly on the type of deficit reduction as well as on initial conditions, the baseline, and apparently minor differences in specification. The dispersion and sensitivity to specification are troubling in that they cast doubt on the validity of the restrictions used to construct the models and indicate considerable uncertainty about the actual outcome of any policy initiative.

TABLE 17. CALCULATED CONTRIBUTION OF LOWER INTEREST RATES TO DEFICIT REDUCTION REPORTED BY BROOKINGS PROJECT (Billions of dollars per $50 billion of static deficit reduction) [a]

	Year 1	Year 2	Year 3	Year 4	Year 5
DRI	3.1	10.7	19.2	27.4	35.9
EEC	3.9	11.0	18.0	24.1	30.2
EPA	5.6	14.7	25.8	39.6	56.8
LINK	0.4	1.5	3.1	5.2	7.8
LIVERPOOL	1.3	3.5	5.4	6.7	7.7
MCM	3.5	10.1	17.8	26.1	35.6
MINIMOD	2.9	6.0	8.4	10.9	13.2
MSG	6.3	20.7	36.1	49.1	62.2
OECD	3.5	10.0	16.6	23.2	30.9
TAYLOR	1.7	4.0	6.0	7.6	9.4
VAR	0.4	1.1	1.6	1.6	1.5
WEFA	3.9	9.5	15.5	22.4	29.8
AVERAGE	3.0	8.6	14.5	20.3	26.8
MAD	1.4	4.5	8.0	11.6	15.7

SOURCE: Adapted by Congressional Budget Office from Bryant, Ralph C., and others, *Empirical Macroeconomics for Interdependent Economics: Supplemental Volume* (Washington, D.C.: The Brookings Institution, 1988) Part III: "Detailed Tables for Simulation Results," pp. 132, 134, 148, 150, 164, 166, 180, 182, 198, 200, 214, 216, 232, 234, 250, 252, 268, 270. Reported values were normalized by CBO as explained in footnote 37.

a. The table is constructed using the assumption underlying the rules of thumb that appear in CBO (1988), p. 63, in addition to the interest rate responses generated by the respective simulations. Because the rules of thumb may not agree with the relevant model specifications, the table entries may not reflect the deficit implications of lower interest rates contained in the respective models.

APPENDIX I: DESIGN OF CBO SIMULATIONS

The simulations conducted by CBO were performed on as many of the commercial macroeconometric models available to CBO as possible. These were DRI's version US86B, Fair's model estimated on September 28, 1987 (marketed under the name FAIRMODEL by Economica, Inc.), and WUMM (as revised in September, 1986). While it is not available commercially, an updated version of the St. Louis model was also used. The reader is referred to other sources for details about these models.[1] All simulations were done in late 1987 using the latest data available at that time.

Because all of the large-scale models used are nonlinear and contain high-order lag structures, the baseline values of the macroeconomic variables for each model should affect the model's response to a given shock. The baseline values used in the cases of the commercial models were the standard forecasts made by the respective vendors at the time.[2] The baseline for the St. Louis model was developed by assuming steady 5.5 percent growth in M1 and projections of other exogenous variables developed by CBO as of August 1987.

To minimize the influence of scale biases arising from different baselines, CBO made the fiscal shocks comparable across models. The fiscal policy shocks were developed as follows. For each baseline, CBO calculated an adjustment to the average effective personal income tax rate that would yield a static increase in revenue of $50 billion in the first quarter of the simulation. This adjustment was

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1. The methodological underpinnings of the DRI model are described in Otto Eckstein, *The DRI Model of the U.S. Economy* (New York: McGraw-Hill, 1983). The Eckstein volume is, however, specific to a now dated version of the DRI model (US1981C). The 1986 version of the model has some strikingly different characteristics. References available at the time the simulations were done, were DRI Model of the U.S. Economy, manuscript, July 1985, and Roger E. Brinner, "The 1985 DRI Model: Overview," Data Resources U.S. Review (September 1985), and the companion pieces by Wyss and Gault in the same issue.

   The best description of the Fair model can be found in Ray C. Fair, *Specification, Estimation, and Analysis of Macroeconometric Models* (Cambridge, MA: Harvard University Press, 1984). The Fair model is reestimated each quarter so that the coefficient estimates reported in Fair's volume are generally different from those contained in the September 28, 1987, version but the underlying structure is essentially unchanged. The WUMM model is described in *The WUMM Model Book & WUMMSIM/PC User's Guide* (St. Louis: Laurence H. Meyer & Associates, Ltd., October, 1986).

   The St. Louis Model is described in Carlson (1986). CBO updated the model to take into account more current data and to allow use of CBO's construction of standardized, or "potential," output.

2. The baseline DRI forecast used in the simulations was their TRENDLONG1087 which is briefly described in Caton, "The Long-Term Outlook," *DRI Review of the U.S. Economy* (October 1987), p. 32. The baseline forecast used in the simulations of the Fair model were five-year extensions of Fair's September 1987 forecast. The basic Fair forecast is summarized in the FAIRMODEL Forecast letter of September 28, 1987. The forecast was extended to cover the years 1987-92 by simply extrapolating the FAIRMODEL forecasts for all exogenous variables to 1992 and solving (using the FAIRLONG software utility). The WUMM baseline used was their long-term forecast of August, 1987, which is described in *The Long-Term U.S. Economic Outlook* (St. Louis: Laurence H. Meyer & Associates, Ltd., August 1987).

then applied to the appropriate tax rate add-factor (DRI) or exogenous value (WUMM and FAIRMODEL), in each case, across the entire simulation horizon. It was assumed that marginal personal tax rates were unchanged from their baseline values. In FAIRMODEL this requires suppressing the equation for the marginal personal tax rate.

Multiplication of the increase in the tax rate by the baseline value of taxable personal income appropriate to each model yields a set of static revenue increases. As Table A.1 shows, these static revenue gains show a nearly constant increase relative to respective values of baseline GNP. For the simulations in which purchases were cut, these same static shocks were introduced as exogenous declines in nominal, noncompensation federal purchases (using the respective baseline shares of defense and nondefense noncompensation purchases). The only fiscal variable in the St. Louis model is high-employment federal expenditures. This variable was reduced by a constant fraction of baseline GNP sufficient to lower its value in the first quarter of the simulation by $50 billion. In principle, the monetary policies considered were to hold either nonborrowed reserves (plus extended credit) or GNP to their respective baseline values. The DRI, WUMM, and FAIR models allow direct control of nonborrowed reserves. The St. Louis model, however, does not contain nonborrowed reserves, so M1 rather than nonborrowed reserves was held to its baseline levels. The simulations that returned GNP to its baseline levels (within 0.1 percent on an annual basis) were conducted by manipulating the federal funds rate (DRI and WUMM), the 91-day Treasury bill rate (FAIRMODEL), or M1 (St. Louis). Using monetary policy in this way requires initial sharp reductions in interest rates in the structural models. Interest rate paths were chosen so that once GNP was returned to baseline levels, it remained there without requiring further sharp movements (relative to baseline) in interest rates.

GNP was returned to baseline levels by the second year in WUMM and the St. Louis model, but this was not possible until the third year in the DRI or Fair models without introducing sharp and wholly unrealistic oscillations in interest rates. In any case, the fact that respective interest rate responses are roughly by a constant in the later years suggests that the differences reflect true long-term model relationships.

No further adjustment of model relationships was attempted. While it can be argued that additional management might be warranted--particularly in the relatively large models with greater detail and greater potential for statistical error (e.g., in the income-expenditure accounting balance)--none was made by CBO since such auxiliary adjustments would have corrupted the rather simple nature of the experiments performed.

TABLE A.1. STATIC FISCAL POLICY SHOCKS

	Year 1	Year 2	Year 3	Year 4	Year 5
	Static Deficit Change (In billions of current dollars)				
DRI	-51.5	-54.9	-58.8	-63.0	-67.7
Fair	-51.7	-55.1	-58.7	-64.7	-71.3
WUMM	-51.4	-55.0	-59.0	-63.2	-67.8
St. Louis	-51.5	-54.9	-58.5	-59.8	-66.3
	Static Deficit Decline (As a percent of baseline GNP)				
DRI	1.1	1.1	1.1	1.1	1.1
Fair	1.1	1.1	1.1	1.1	1.1
WUMM	1.1	1.1	1.1	1.1	1.1
St. Louis	1.1	1.1	1.1	1.1	1.1

APPENDIX II: METHODOLOGY AND LIMITATIONS OF MACROECONOMIC MODELING

There are several approaches to constructing a macroeconomic model--each with drawbacks of its own. The methodology and limitations of these approaches are discussed below.

METHODOLOGY OF MACROECONOMIC MODELING

Modern approaches to macro model building can be represented by two polar extremes--structural and nonstructural.[1]

Structural Modeling

The structural approach uses theory a priori to limit the range of hypotheses consistent with the data.[2] The determination of which variables are to be included in the model, as well as of which are to be treated as exogenous to the behavior of a given sector, for example, is based on theoretical grounds (e.g., the assumption of cost-minimizing behavior by firms). Examples of particular models that represent this statistical methodology include the conventional income-expenditure models whose simulation results are reported in the text, as well as the rational expectations models of Sargent (1976a), Barro-Rush (1980), and Taylor (1979).[3]

Nonstructural Modeling

As its name implies, the nonstructural approach to macro model building does not rely on a priori theoretical structure. Vector-autoregression (VAR) modeling is an example of such an approach.[4] In its purest form, instead of introducing restrictions to limit the number of hypotheses consistent with both the data and the model, all variables in the system are assumed to be endogenous. Each variable in

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1. The SEMTSA approach of Zellner (1978), and the index models of Sargent and Sims (1977), represent efforts to bridge these polar extremes.

2. These restrictions are referred to as identifying restrictions. As a practical matter, not all restrictions applied in estimating a structural model derive from theory. For example, lag lengths are usually chosen on statistical, rather than theoretical, grounds.

3. Typically, conventional income-expenditure models, with the exception of FAIRMODEL, are estimated using Ordinary Least Squares (OLS)--a technique that ignores the simultaneous nature of the posited relationships. It is usually argued that OLS is less sensitive to inappropriate specifications than simultaneous estimation methods.

4. The VAR school is taken here as representative. The vector ARMA, or VARMA, is more general in that it can contain moving average as well as autoregressive components, but it differs little from the VAR with respect to the treatment of structural restrictions implied by theory. The methodological differences between the two approaches seem to center on the adequacy of stationarity as a maintained hypothesis.

the system is assumed to depend on the same number of lagged values of all variables in the system. The only types of restrictions introduced in the pure VAR approach are those governing lag length and the rules by which variables are to be included in the system--restrictions imposed by computational limitations.[5] The estimated coefficients of a VAR model depend solely on the observed statistical correlations (both contemporaneous and lagged) among the system variables.

An estimated VAR model, however, does not necessarily imply any structural interpretation. In general, it will be consistent with more than one structure so that determining the true structure will require additional restrictions.[6] In advancing this approach, the leading proponent of the VAR method argues that the restrictions used in specifying structural models--both income-expenditure and rational expectations models--are not credible. In particular, he questions the assumption of the statistical exogeneity of policy variables. See Sims (1980,1988).

Reduced-form estimation represents another nonstructural approach. In this approach--as in the structural approach, but not in the VAR approach--variables are represented a priori as either endogenous or exogenous. Together, all exogenous and lagged endogenous variables in the system constitute the predetermined variables of the system. Each endogenous variable is then considered to be determined by all the predetermined variables of the system. Unlike the VAR approach, each equation in the system may not contain the same past values of all the other variables in the system. If one accepts this approach, it allows consideration of how the system responds to changes in contemporaneous exogenous variables, including exogenous policy variables. As with the VAR, however, the resulting estimated model will generally be consistent with more than one structure.

LIMITATIONS OF MACROECONOMIC MODELS

Each of the approaches outlined above has its limitations. In the case of the structural approach, the most obvious problem is that a given specification will typically not allow for the statistical testing of structures based on alternative theoretical frameworks. In the case of the nonstructural approach put forth by the VAR school, the interpretation of tax and expenditure changes as strictly policy-induced shocks to the system is difficult at best. The reduced-form approach admits such an interpretation, but, as with the VAR, the structural linkages among variables cannot, in general, be retrieved from the estimates.

No macroeconomic model can be validated solely on the basis of an appeal to the data. This is true for several reasons. Most fundamental is that all macroeconomic theories depend to some extent on unobserved variables (for instance, the natural rate of unemployment or expected future prices or interest rates). This

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5. It is possible, however, to consider VARs that contain exogenous variables and to introduce restrictions that allow for the estimation of larger models. Loosely speaking, such restrictions are typically of a statistical, rather than economic, nature.

6. This problem arises because the innovation (equation error) in any equation of the nonstructural VAR representation is itself some linear combination of the innovations in all the equations of the structural representation.

implies that a given macroeconomic data set will be consistent with more than one theoretical hypothesis.[7] The problem is compounded by the paucity of macroeconomic data available, which severely limits the types (in particular, the size) of macroeconometric systems that can be estimated.[8] Interpretation of model simulation results thus depends on accepting the restrictions imposed on the specification and estimation of the model itself.

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7. This is related to the observational equivalence problem discussed in Sargent (1976b).

8. This can be termed a degrees-of-freedom problem. There are not enough observations to estimate precisely very many relationships. This problem is exacerbated by the fact that economic time series tend to move together over the course of the business cycle so that it is difficult to disentangle their separate effects. Since the United States has had only limited periods of large deficit spending--basically, the war periods--the historical data used in the estimation of macro models may be simply inadequate for the representation of the effects of large peacetime deficits on interest rates. Another relevant aspect of the data problem is the finite-sample problem. Virtually all inferential methods used in econometric model building rely on the large-sample properties of the coefficient estimates obtained.

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